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THE LIMITATIONS OF TAXONOMY[1]

IT is a matter of common observation that taxonomic work in entomology is more highly regarded than formerly. I remember less than thirty years ago, when a student of mine went to an eastern entomological center for advanced work, he wrote back to me that no courses in classification of insects were provided; the students, he wrote, were supposed to work this up on the outside. Now in the same institution are offered a series of taxonomic courses in entomology, covering most of the orders. Even at the beginning of the present century, very few entomologists occupied positions where classification was a recognized part of their duties; generally those who did the necessary identification work were paid ostensibly to do something else. But now we find a considerable number of taxonomic positions in entomology in the United States—not all as well paid as they should be, of course, but hopefully established. The great expansion of economic work in entomology has made exact identification a fundamental requisite, as is now universally recognized.

From this fairly secure position I wish to survey the field and point out some limitations of taxonomy which make me doubt whether even within our own fraternity the difficulty of our task is fully appreciated, and whether without a more general appreciation of the requirements of our science we can hope in the next few decades to approach in any acceptable degree toward the ideals we hold.

The first and most obvious difficulty is the inconceivable number of species to be classified. I can well remember when a venturesome but far-seeing entomologist predicted that the living insect species of the world would ultimately be found to number at least a million. At the time many thought the estimate extravagant; but now it is seen to be far too low. It is claimed that the number now described and named is about 640,000, and the annual additions run far into the thousands. Walther Horn has recently put the difficulty this way:

> Whoever as an entomologist looks into the future knows full well that we are steering into a shoreless sea, no matter whether he estimates the total number of insect species at three, ten, or fifteen millions. In the near future any beginner will be grayheaded before he has caught up with what is already known.

[1] Address of the retiring president of the Entomological Society of Washington.

I am reminded of a proposal made years ago by Professor Burt G. Wilder, who was an enthusiast on the structure of the brain. In a published article he lamented the fact that a student beginning in college to specialize on the brain could in the course of an average lifetime just about catch up with what was already known, leaving him no time to make further discoveries. The professor proposed in all seriousness that the study of the brain must be commenced at an earlier age, suggesting as I recall that about eight or ten years would be a suitable one for the beginning student. We might consider the same course in entomology, but even this would relieve the situation for only a few decades, when the increased number of species would fill the time as full as it now is. Obviously nothing but more narrow specialization can overcome the handicap of expanding numbers; later I shall recur to the disadvantage of this.

Another physical difficulty lies in the fact that the larger part of this great host of insect species is not yet captured. Before they can be classified they must be collected and preserved for study.

Allied to this is the almost insoluble problem of seeing the types, when as usual those desired are scattered in museums over the world.

Yet another physical difficulty is the task of assembling the library and indexes which will enable the student to work under proper conditions. And this difficulty increases even more rapidly than the number of insects, as the books required become not only more numerous, but more costly. When I began to study Diptera in 1890 there were but a few expensive works on the subject to be bought; in the succeeding years I was able to add what followed so gradually that it was not a severe tax to build up a library in the order. But the beginner must now be prepared to spend liberally, or else must establish himself in an institution where a large library exists; if he work by himself with only a few books, he will have to confine himself to a very narrow specialty indeed. The indexes present a problem even greater, for they take a vast amount of labor in preparation and are found in only a few places, and even there are more or less imperfect, often including only North American species. If the worker make his own, this is another factor holding him to a narrow field.

If we assume the impossible case that the taxonomist has overcome the difficulties mentioned and has assembled all the material, including types, and all necessary library and indexes, he is ready to proceed with a natural classification of the group. That is, according to the ideal generally accepted, he must make his classification conform to the evolutionary history and relations of the group. How is he to ascertain these? To show how much is involved, I will mention the lines of approach he is supposed to use, taking them from Heikertinger's convenient review of Karny's new book, "Methods of Phylogenetic Investigation," with some explanations of my own.

(1) Paleontology. In the higher insects this is a field but little explored. The fossils as far as known are useful principally for the higher categories, and for the lower orders.

(2) Geographical distribution. This may throw light on the evolution of existing forms and is generally far more useful for relationships of genera and species than the preceding.

(3) Ontogeny, or the development of the individual. This is an application of the biological law that the individual in its development recapitulates the evolution of the species to which it belongs. There is scarcely a group of animals in which the application of the law is attended by greater difficulty than in insects, especially the higher forms. In Diptera, for instance, the larva is not ancestral to the adult in structure, but rather a side development, as Comstock has pointed out. This cuts out the later ontogeny, leaving only the early embryonic stages to be considered, which at best are significant only for the higher categories.

(4) Morphology. This is what is generally used, almost to the exclusion of other lines of study.

(5) Ecology. This may indicate causes of variation in climate or immediate surroundings.

(6) Teratology, the study of monstrosities, which sometimes are much more primitive than the normal form of the species. For instance, Professor Wheeler once figured a specimen of Dilophus having a supernumerary antenna growing out of a fore coxa; this antenna was of a much more primitive kind than that of the normal Dilophus, and seemed to indicate that Dilophus is a derivative of the Nematocera, which in this case is abundantly confirmed in other ways.

(7) Experiment.

(8) Chemical and serological methods.

Merely to enumerate this list is to show how far we are from the ideal classification as yet. We rarely see any important use of factors other than morphology and distribution.

One of the fascinating but difficult problems of classification is what to do with complex species. We all know that the geneticists have produced a host of Drosophilas which if occurring in nature would be called distinct species or genera, but which are explained as being merely assortings of the hereditary matter in the chromosomes. When we know the secret of their origin we can not call them species; they are more like the breeds of domestic animals. But amid other species in nature we may be misled by the occasional occurrence of a striking

form arising in the same way, which looks to us like a true species.

There are also in nature the well-known cases of insect strains, where habit differs and is inherited in the apparent absence of structural characters. For instance, *Exorista larvarum* of Europe attacks both the gypsy moth and the brown-tail moth, while in this country the same fly, as far as structure indicates, attacks neither. The apple maggot fly has apparently produced two offshoots, one of which attacks the blueberry in Maine, the other the snowberry in British Columbia, while neither troubles the apple.

A few miscellaneous cases may be added. There are many species of plant lice which have two host plants migrating from one to the other at certain seasons, and changing on the second plant to a form which taken by itself would be supposed to be quite a different genus from that on the first. Dr. A. C. Baker, you will recall, recently stated in our society that when he transferred a certain aphid to a different food-plant from the normal one, in a few generations he detected constant differences in the anatomy; these differences might have been the basis of a new varietal name if he had not known the history of the case. Mr. S. A. Rohwer tells me of a parallel case in sawflies, where he had drawn up the description of a new species, but happened before publication to discover that it was a known species transferred to a different food-plant. Mr. H. S. Barber finds that fireflies at Plummer's Island have a certain mode of flashing at one time in summer, and two weeks later a different one. The seventeen-year locust has a little brother with a shrill voice, which has been given a different specific name. I have recorded that in the middle west the pale *Cerodonta dorsalis* changes in its late fall brood into the dark form *femoralis*, characteristic of the Rocky Mountain region. A series of classic experiments have shown how light and dark forms of Lepidoptera may be produced by modifying the temperature and humidity during the pupal period. The beetles inhabiting the narrow, cold coastal strip of Oregon and Northern California are darker in color than the same species living a few miles farther inland. Dr. W. R. Thompson has lately published figures of three recognizable forms of first-stage larva in *Masicera senilis*, the later stages of which seem to be all alike. Similarly Dyar and Knab found a number of cases in mosquitoes where two distinct larval forms produced apparently a single species of adult.

These are only a few illustrations of what I mean. The problem I wish to call to your attention to in this connection is the difficulty of expressing such complicated and varied relations in the scientific name. We are limited to two or at most three words, and it seems to me that the mass of information we are asked so to convey is beyond the capacity of language. If we trust to varietal names, we shall have so many different kinds of varieties that the traditional use of this category for minor structural differences will be completely obscured.

Somewhat akin to the preceding are the difficulties arising from the introduction of new groups of characters, especially those of the larvae. It is natural to assume that the larval characters can not contradict those of the adult when brought into the taxonomy, and yet in the higher orders, as the Diptera, where the present larval form is not ancestral, the statement is not axiomatic. Our existing classification of the adults may be a misinterpretation of evolution which can be corrected by reference to larval characters; but it is just as likely that we are misinterpreting the larval characters, which have been as yet so little studied. I would not mention genitalic characters here as presenting a difficulty in separating species, for they are helpful in the extreme; they do, however, lead to new combinations in genera and are as much subject to misinterpretation here as the larval characters.

So far I have been dealing with physical limitations, tending as I think to delay or prevent the consummation of a complete classification of insects. I now pass to certain difficulties of a much more complicated order, the psychological or subjective ones, which have to do with the mentality of the taxonomist. It was for some time my intention to call this talk "The Psychology of the Taxonomist," but I finally decided to take in the physical factors.

The taxonomist has on the average no special psychological peculiarities, but I think in him the working of ordinary processes will account for some common deflections of judgment.

One of these processes is the magnification of one's own work or property, by virtue of which in a few years of study an entomologist becomes convinced that the suborder with which he works ought to be considered an order, the family ought to be two or three families, and so on. I had been working only a couple of years on Diptera when I got hold of the Hyatt and Arms treatise on insects, in which Dr. Hyatt expressed the opinion that the Diptera are the highest of all the large orders. I was delighted with the idea, so much so that I published an article in SCIENCE (XIX, 1892, p. 244) endeavoring to support it. For a number of years I was thrilled when I thought that my favorite order was the highest. But that was a good many years ago; now I feel no personal interest in the matter. I might add that my article drew a note from a dipterist who was specializing in the housefly group, in which he claimed

that the housefly, and not as I had thought the sheep-tick, is the highest of insects.

It is of course an equally common fallacy to attach too much importance to a thing simply because it is close at hand. This error is akin to the preceding, but can be separated in part at least. Probably the reason so little attention is paid to fossil insects, or to exotic forms, may be looked for here. The indifference of most entomologists to insects from outside the country or region to which they limit themselves is almost appalling. One encouraging sign of the times is the change in this regard in the United States within ten or fifteen years, in which I am happy to say the National Museum is taking the lead.

The subject can not be analyzed without mention of the case where the individual is so ambitious to attach his initials to as much as possible of the framework of classification that he seems bent on introducing the greatest possible number of new names. It is hard to diagnose some cases clearly, as an entomologist may merely be infected with the idea that all change is improvement; or he may honestly and perhaps with justice believe that previous work in his specialty has been notably poor.

Of all fallacies in taxonomy, the all-pervading one is that the relationships are better expressed by the continual dividing of the categories. We "raise" a suborder to an order, a subgenus to a genus, etc., world without end. The result achieved is generally a reduction of the value of the term—in other words, the inflation of our taxonomic currency. I think it no exaggeration to say that the family has about half the value now that it had when I began, and the genus probably one fourth. These changes have been made without materially altering the indications of relationship, which were just as clearly evident before inflation as after.

In this connection it might be worth while to consider this fact; suppose a class of animals—any class—to be divided into twenty-eight orders; each of these to be divided into twenty-eight families; each family into twenty-eight genera; and each genus into twenty-eight species. We should then have provided classification for 614,656 species, or by chance almost exactly the number now known in Hexapoda. Of course no one would think of suggesting that every genus should have twenty-eight species, but should not the law of averages have some scope in a number so immense as 600,000?

There is one phase of the matter which does not always receive consideration. Classification has two functions—to express the relations between organisms, and to give us names for the different kinds which shall be stable and universal. Linnaeus worked out the idea of a scientific name consisting of the genus and species; the latter was the name proper, while the former connected the species with a group of similar forms. One name defined, and the other located the species. The genera of Linnaeus were comprehensive, about like the family of the present day, which was absent from his scheme. Immediately after the publication of the tenth edition of Linnaeus, Geoffroy proposed to divide the genus, where large, into families; the idea was not accepted, however, and some years later the family came in again, this time to be accepted, as the next category above the genus. I have often thought that our scientific names would better fulfil their function if Geoffroy's scheme had been followed. Under it the generic name would still be as comprehensive as our present family name, a great advantage over our existing system, under which the genus often fails to connect the species with any other whatever, and in many other cases with only one or two.

In the second part of Brauer and Bergenstamm's large work on the Muscoids of the Vienna Museum, this sentence occurs:

> Whoever works with a narrow group that is rich in species and begins to separate these, ascending from the smallest groups to higher ones, easily falls into error regarding the value of categories; for it is easy to distinguish so many within the limits of a single genus that is rich in species that, *without keeping in view the entire field of zoology*, it seems that all the categories repeat themselves within the single genus.

Here is the explanation of the error; we do these things without keeping in mind the whole field of zoology. In our little field we readily distinguish several orders of groups, one above the other; and without the survey just mentioned, we attach to these the names which in the broad view belong to larger categories. It is the commonest fault of taxonomy, and one to which the beginner is especially likely to fall a victim. He soon comes to feel that the conservative course is likely to be interpreted as inability to see characters.

There may be less difference than is commonly supposed between splitters and lumpers in what they see—the difference may be far more in the terms they use. This is especially true in the matter of genera. In fact, a taxonomist may be a lumper in genera and a splitter in species, and I think a good deal may be said in favor of this position.

It will, I think, be apparent that there are great and varied difficulties in our task, and as we contemplate the future they seem even more serious. As specialization becomes ever more narrow, it will continually be harder to attain the perspective which alone can guide to the correct use of the chief cate-

gories. Intensive study is already modifying our idea of the species to a great extent, so much that some are beginning to doubt if such an entity exists; and yet without it we are completely undone and will have to begin over again. The physical and personal limitations of those who do the work must always keep the quality far below the ideal which I have discussed. Criticism is usually a generation behind publication, so that the poorest work may stand, as we often see, for twenty or forty years before it is competently revised. Moreover, the ablest taxonomists are likely to be the very ones to succumb to the higher rewards of administrative and economic work, and so fail to make the contribution of which they are capable.

I wish I could close with a strain of optimism, but the best I can say is this: Taxonomy demands the highest talent, and those who prove their fitness should have every facility and inducement; there is increasing recognition of this fact, and here lies the only hope that this basic science can perform for humanity the service demanded of it.

J. M. ALDRICH

U. S. NATIONAL MUSEUM

THE ELECTRICAL ENGINEERING RESEARCH SITUATION IN THE AMERICAN UNIVERSITIES

PRODUCTIVE research is both the criterion and vehicle of scientific progress. This fact makes university research of especial importance, not only because of the additional knowledge that is obtained, but also because of the close relationship existing between collegiate research and scientific education. In view of the great amount of discussion going on at the present time regarding engineering education it is interesting, and very much worthwhile, to investigate the research situation in the technical schools of this country. The following paragraphs give the results of such an investigation into the field of electrical engineering.

It is a relatively simple matter to determine with satisfactory accuracy the amount of productive research being done in our electrical engineering schools. Practically all researches of permanent value which American electrical engineers perform are reported in the *Transactions* of the American Institute of Electrical Engineers. To obtain a very good idea of the electrical research being done in this country it is merely necessary to count titles in the *Transactions* for a period of years, omitting articles from foreign sources, presidential addresses, and papers of a general nature which do not represent contributions to science. Fortunately nearly all the articles published in the *Transactions* are of a technical nature, and represent research work of some kind, or at least the accumulated experience gained by years of observation of electrical equipment.

During the six-year period from 1920 to 1925, inclusive, 442 technical articles appeared in the *Transactions*, of which 54, or 12.2 per cent., had a college source. This gives an average of nine papers a year as the annual production of our many teachers of electrical engineering and of their students doing thesis work. Considering the results separately by years gives the following table:

Articles in *Transactions* of the A. I. E. E. 1920–25

Year	Total	College	Per Cent. College
1920	60	5	8.3
1921	36	3	8.3
1922	66	5½	8.1
1923	80	13	16.25
1924	113	13½	11.95
1925	87	14	16.1
Total	442	54	12.2

The fractional titles are the result of joint authorships. It is to be noted that while the amount of research being done in America in electrical engineering jumped very greatly as soon as research programs got under way after the war interruption, yet the proportion coming from colleges is substantially constant, and is in all cases surprisingly small.

It might be expected that the remarkable development of the radio field in recent years would absorb much of the creative effort of electrical engineers. Analysis shows that such is not the case. A survey of articles appearing in the *Proceedings* of the Institute of Radio Engineers for the six-year period from 1920 to 1925 shows that 174 articles were published, of which twenty-seven and one half, or less than five per year, had a college source. Furthermore, the radio field goes so far into the realms of the physicist that over half of these five articles per year must be credited to physics rather than to electrical engineering.

The results given above do not include all the research results published by electrical engineers, for the electrical engineer does not always report his researches in the publications of the national radio and electrical societies. From time to time important articles which should be credited to electrical engineering appear in other places, particularly in the magazines of the physicists and mathematicians. However, a glance at the bibliographies of electrical engineering papers shows clearly that the number of such stray articles that should be credited to the American electrical engineer, and particularly to the engineering schools, is relatively small, and can be

neglected without impairing conclusions drawn from the data already given.

In the six-year period considered fifty-four technical articles from a collegiate source appeared in the *Transactions*, and forty-three and one half of these fifty-four are credited to five colleges. The remaining several hundred schools of electrical engineering together produced ten and one half articles in six years. Only one electrical engineering department produced more than two radio papers in the six-year period. The following table gives the universities having productive electrical engineering departments:

Articles in *Transactions* of the A. I. E. E. 1920–25	
Mass. Inst. of Tech.	15
Johns Hopkins	10½
Stanford	9
Cornell	5
Purdue	4
Articles in *Proceedings* of I. R. E. 1920–25	
Columbia	7

The researches reported by the universities cover a very wide range of subjects. The high voltage field is most popular, but articles are found covering practically every phase of the electrical industry except certain of those branches that can only be carried on by national organizations, such as the telephone company.

The number of men with university connections who are active in research work is rather small. Considering a college professor as a productive research worker if he and his students together turn out one technical paper of scientific value every two years, it is found that in the six-year period from 1920 to 1925 there were eight productive research workers on the staffs of our electrical engineering schools, and these eight men and their students produced over half of the university research. Three of these were at Massachusetts Institute of Technology, while the other five were distributed one to a college. Only one of the eight published anything on radio.

The summary of this survey shows that the electrical engineering schools of our country produce about one eighth of the electrical and radio research that is reported in the pages of the national engineering societies. This represents about eleven articles a year. Of these eleven articles coming from the colleges each year, approximately seven come from four universities. Apparently not over a dozen technical schools are making much if any effort in the way of research. Over half of the university research in electrical engineering is the work of eight men.

This is the situation, and it now remains to consider the consequences of this condition. University research in electrical engineering is primarily significant as an indication of the situation that exists to-day in the education of electrical engineers. The laboratories of the big electrical companies make technical progress assured even without any university research, but the country's supply of technically trained young men can come only from the university.

Research means progress, and above all things it signifies that the producer of research must be an authority on at least one subject. It is safe to draw the conclusion that an institution which turns out research work in a certain field of engineering will be able to give its students the best and latest that is to be had upon this subject. This makes it evident that an institution which is performing research work in practically all lines of the electrical industry is best fitted to give its students the broadest and most up-to-date training possible.

While the research worker must be an authority, it is possible to be an authority without being a research man. Possible, to be sure, but not likely, for the university man who keeps in touch with everything and who understands the significance of new developments will be continually getting ideas. It is a very unusual man who will keep up in the firing line of progress and not lift his own hand or direct the hands of his students in an effort to advance the front. Almost inevitably such a person upon reaching the front line will either put his shoulder to the wheel or will stand still and let the rest of the world go on ahead. The electrical industry is so new and is progressing so rapidly that one can lose out completely with new developments in a period of from five to ten years, and a man who received the very best of training ten years ago is entirely out of the running now unless he has kept moving ahead. This makes one begin to suspect that perhaps most of our electrical engineering schools are trailers of the electrical industry in general, rather than leaders of progress, as generally assumed. There are very few colleges that can give as good an answer to a "red-hot" question in electrical engineering, as the engineer in the laboratories of the General Electric Company, Bell System Laboratories, etc.

This is the situation; why does it exist? Lack of equipment can be dismissed at once, for although some electrical researches require expensive equipment, there are many that do not. Pencil and paper constitute the main essentials for the investigation of many problems. There are probably a great many factors that enter into the matter, but the most important undoubtedly are first, heavy teaching schedules which leave little or no time for study and research; second, lack of adequate training of teachers

of electrical engineering; and third, the fact that research is often much more poorly rewarded than other activities in which the engineer may engage.

The overworked instructor is met on all sides. His plight is unfortunate, but the fact that he has no time for research between his lectures explains but does not remedy the situation. Excessive burdens imposed on the teaching staff do not directly stifle original investigation, for students do a large portion of the time-consuming part of the university research. The effect of overwork is principally to make it impossible for the harassed individual to do the studying that is necessary if one is to keep up with industry. The inevitable result is that students are often taught by men who are unable to keep up-to-date, and these same students do thesis work which is inadequately supervised and is usually on antique problems.

Inadequate training of teachers is perhaps the greatest handicap under which electrical engineering education suffers. The general ideals of what constitutes a well-trained engineer are very low. A great fraction of the young men on the instructing staffs have received only the bachelor's degree and are not planning to go beyond this point. Some possess a master's degree, but extremely few have gone so far or ever expect to go so far as the doctorate. Compare this with chemistry or physics, for example, where the best schools will not give permanent appointments to a young man who does not have the Ph.D. degree or who is not very near this point. The low standards that prevail in the training of engineering teachers mean that the young instructor spends many laborious years educating himself to make up these deficiencies as best he can. A couple of years of graduate study would do the job much more thoroughly and leave the remaining years for productive research rather than for self-education.

Most colleges do not expect the teacher of engineering to do research as part of his job. They are pleased if he carries on original investigations, but he is not expected to do so and is usually not rewarded in a concrete way for such work. The able teacher who has a little spare time can more profitably employ it in building up a consulting practice. To be successful in this requires that the consultant possess more technical knowledge than his clients, but this does not necessarily imply a great deal of scientific knowledge. Other teachers write text-books for elementary students of electrical engineering—an occupation that has vicious possibilities. It gives us poorly trained teachers writing poor text-books which will inadequately train future teachers who will write still more books.

The tendency of the research situation that exists in electrical engineering is to create a self-perpetuating system in which a second-rate technical education is considered first class because of general ignorance that there might be something better. The student leaves college thinking he is thoroughly trained when he is only acquainted with the shadow of the real thing, and he does "research" work in obtaining an advanced degree that is not research in any sense. Giving a motor a thorough routine test or reworking some problem that was solved twenty years ago is not research in the true sense, even though the process may be new to the student.

All the facts that have been presented are decidedly important in their effects on engineering education. To improve technical training, well-trained instructors having several years of graduate study are essential, and these men should be expected, and should be given the time, to follow closely technical progress. Curricula won't help very much, for a curriculum does not of itself educate. If it did, every college in the country could adopt the curriculum of the Massachusetts Institute of Technology and be able to offer the same brand of training without a change in the instructing staff. It is practically as easy to direct a student's thesis activities on really new problems that are yet unsolved as it is to have him work on some problem that is new to him only—provided competent supervision, backed by original ideas, is available. Practically every thesis investigation should be spent in obtaining evidence and facts that will at least contribute to future published work on the part of some one.

Many of the important aspects of engineering education are not appreciated by the ordinary engineer, who has too often had no opportunity to gain a conception of what constitutes thorough training or genuine research. Questionnaires sent to practicing engineers are valueless as far as such matters are concerned, and the usefulness of the questionnaire anyway is dubious in deciding most of the problems of technical training. The psychologists long ago discarded the questionnaire method of ascertaining *truth* and now use it only where they desire *opinions*. In fact, the educational opinions of most college-trained men are unique. As President Wilbur has put it, the college graduate buys a 1927 automobile, a 1927 radio set and a modern house, but he clings to the college of his youth and wants his children to have the same education he obtained, an 1899 model.

This situation probably exists in other branches of engineering to about the same extent as in electrical engineering, although the writer is not in possession of the detailed facts on this point. There is a common feeling that something is not just right with engineering education, but it will take more than questionnaires and symposiums on curricula to get

us far enough out of the present rut to show that there are better paths within access. At present we are content to pay homage to Steinmetz, Pupin and Tesla, while making no effort to offer at home the thorough training these men obtained elsewhere.

FREDERICK EMMONS TERMAN
STANFORD UNIVERSITY

WHAT IS A PLANT?

A PLANT is a living thing, typically green, possessing a green pigment, chlorophyll, by means of which it absorbs a part of the energy of the sunlight; by means of this energy it decomposes carbon dioxide; it uses the carbon, with water, to form its carbohydrate food; since its necessary food is everywhere, it does not have to have the power of locomotion; and since it does not have to move, it can protect itself with rigid walls of cellulose. . . .

But,
there are animals which during the most of their lives are fixed in one place as securely as typical plants are fixed. Some plants at all stages of their lives, and many plants at some time in their lives, have the power of locomotion, or at any rate are freely moved about. While plants are typically green, it is not impossible that the time will come when more kinds of plants are known without chlorophyll than with it. . . .

Why, then, are they called plants? Not because they have the majority of the characteristics of plants; for they are not green, and can not use carbon dioxide as food, and they may have the power of motion and be destitute of cellulose. Yet they are plants. The reason goes back to the idea that the plant kingdom is a group of creatures which are really related, which have common ancestors. Any living thing which is descended from the ancestor of the plant kingdom is itself a plant, whether or not it has retained the typical characters of plants.

Still farther back, there was doubtless a common ancestor of both plants and animals; and there are living things in the world which are less related to plants than animals are, and less related to animals than plants are.

This is commonplace, indeed; so elementary that it can be quoted from an old text for beginners averaging perhaps sixteen years in age. It is intruded on the—perhaps bored—attention of the professional botanist and teacher, because, as logical as a good lawyer, and hardly less the slave of precedent, he constantly ignores its consequences. Quoting still from the same very elementary text:

The plants and animals which we see about us seem very different indeed. A man or a horse differs from an orchid or a sunflower as widely as the time that plants and animals have existed upon the earth has permitted the difference between living things to become. If we follow the line of plant development backward or downward from the sunflower, we will find the characters which make up our usual idea of a plant gradually to disappear. The first to go is the showy structure of the flower. . . . The seed goes next. No seeds are found among the Archegoniates. Leaves are still present, but if we move downward to the next lower group, we shall lose them also. . . . If we follow the line down to the lowest Algae, we come to plants which no longer show any suggestion of a distinction of roots and shoots. . . . Still, these lowest Algae are plants. . . . If we begin at the top to follow down the line of development of the animal kingdom, we shall see the characteristic structures of the higher animals, hair first, then bones, etc., disappear, as did the flowers, seeds and leaves of the higher plants. At the bottom of the animal kingdom, we come again to organisms each of which consists of a single cell, but this cell still an animal. However unlike the higher animals and the higher plants may be, when we come to the examination of the plants and animals which are single cells, we find that these one-celled organisms, plants and animals are infinitely more like each other than either is like the highly developed creatures which have descended and been developed from them. The animal kingdom, like the plant kingdom, may well be pictured as a tree, and we have come now to the point where it must seem exceedingly probable that the two trunks grow from a common root.

There are many one-celled plants, and many one-celled animals. . . . Some of these share the characters of the two groups so impartially that the question, which they really belong to, is merely one of definition. The definition of a plant may be made to include them, and so may the definition of an animal. Neither is the question, to which kingdom they belong, of any real importance. If two trunks grow from a common root, who shall decide to which trunk the root belongs?

This much we can say: from green flagellates the plants are descended, and from colorless flagellates, the animals. Since the plant kingdom is reasonably spoken of as constituting a vast group of living things for the sole reason that all of these living things have a common descent from the green flagellates, it follows that there can be no possible good reason for calling any living thing a plant, unless it is descended from these green flagellates.

There are alternatives, to which we will return.

There is no reason why other lines of development should not have arisen from the fundamental flagellate stock; and the flagellates themselves are not so primitive, but that they must in turn have had their ancestors; and these ancestors ought not to be included in plants or in animals. There are a large number of organisms known, which, for one or the other of these reasons, must be regarded as neither plants nor animals. . . . For instance, the group of the Chytridineae, which usually have been included among the Fungi, seem very probably to be descended directly from the flagellates, independently of the line of primitive Algae from which the plant kingdom has developed. If this is the case, they are not, in the sense of systematic botany, plants at all, but a distinct group of living things.

Beside the two great trunks which grow from the common flagellate stock, other shoots have evidently started. There may well have been many of these, which disappeared from the face of the earth. There are probably several which still exist, but none of these have been able to develop into great kingdoms as have the two main trunks, the plants and the animals. . . .

"The most primitive living things of which we have knowledge, and therefore the most probable ancestors of all the living things in the world . . . are certain of the Schizophytes"—those able to live independently of other living things or their products. The text quoted goes on to treat of the Schizophytes as a distinct kingdom of living things, less conspicuous than plants and animals, but probably first in the number of individuals and of really great importance in its relations to humanity.

Besides these three great kingdoms, there is a whole list of "The Minor Kingdoms of Living Things." Here are listed the Flagellata: The Protozoa, including the rhizopods, Heliozoa, Foraminifera, Infusoria and others, not farther discussed because, by settled usage, they are subjects of the zoologist: Myxomycetes, which receive the usual couple of pages; Chytridineae: Peridineae: Phaeophyceae, treated in their aspects of general interest, but without any such detail as is usual when they are regarded as true plants: Diatoms: and Volvocineae. The Florideae and Conjugatae would as well have been added to this list. This was not done, because the guiding principle in the setting up of the minor kingdoms was not the lack of evident relationship to the plants, but rather the more or less established direct connection with organisms lower than those recognized as plants.

I have quoted the old text, in preference to presenting the same matter anew and perhaps better, because it is in contrast with other texts. The function of a text is to present the subject acceptably. Up to a decade ago, perhaps five hundred students were given the presentation quoted: three score of them have been sufficiently attracted to scientific work to take master's degrees, and two dozen have doctor's degrees. No new argument could carry any such force of demonstrated effectiveness.

In the light of time, the old text looks quite dogmatic. There is no logical necessity of drawing the bottom line of the plant kingdom between the flagellates and the algae. There are two evident alternatives. The line of recognized plants may be carried down to the beginning of life, in which case animals are to be recognized as a branch of the plant kingdom; this alternative has always been open and evident, but has made no general appeal. Or, a bottom line might be drawn somewhere else. The line is arbitrary, wherever drawn. On general principles, the most primitive green flagellate makes an attractive parent of the plant kingdom; but the breaking up of flagellata into natural groups, whether or not based on color, seems to be decidedly more difficult than the recognition of a line between the group as a whole and the algae.

The choice of any one of the elementary texts in common use, to illustrate the contrast with the presentation given here, would be invidious. The commonest basic guide of their authors is almost certainly Engler's classification, most compactly presented in the "Syllabus der Pflanzenfamilien." No boundary of the plant kingdom seems to be fixed, except by inference. In the ninth and tenth edition, 1924, pp. XXXVI and XXXVII, are listed thirteen divisions. In the body of the book, the first ten are treated on thirty-eight pages, while the remaining three take up 335. Comments under these first ten are:

(1) Schizophyta: "No direct connection with higher plants."

(2) Myxomycetes: "No connection with higher plants."

(3) Flagellatae: "Related to Dinoflagellates, Silicoflagellates, Diatoms, Conjugatae, Chlorophyceae and Phaeophyceae."

(4) Dinoflagellates or Peridineae: "Connected with Diatoms."

(5) Diatoms: "No connection with the higher divisions."

(6) Conjugatae: "Connected downward with the Flagellatae, without connections upward."

(7) Chlorophyceae: "Connected downward with the Flagellatae; upward, a step to the lower Embryophyta."

(8) Charophyta: "Very isolated."

(9) Phaeophyceae: "Connected downward with the Flagellatae; no connection with higher divisions."

(10) Rhodophyceae: "Very isolated," but descent from Schizophyta suggested.

The remaining three divisions are fungi, embryophyta asiphonagama and embryophyta siphonagama, the last two more familiar as archegoniates and spermatophytes.

Seven of these are avowedly unrelated to plants, if the "higher divisions" represent what plants really are. Four constitute a group of clearly related organisms—the things every man recognizes as plants. I would add to these the charophyta, until it is shown to belong elsewhere. And the only objection to adding the flagellatae is that the result is an increase of difficulty in definition and natural classification. But why are the unrelated seven divisions to be included? To do so clearly violates the principle of phylogeny, which Engler constantly and rightly emphasizes as the guiding principle of his treatment and of all rational taxonomy.

If one suggestion of Engler's is adopted, the violence done to the guiding principle of phylogeny is still worse than if currently accepted views are correct. "Mir scheint die Annahme berechtigt, dass bei der Entstehung einzelliger Organismen gleich anfangs mit verschiedenen Genen ausgestattete Schizophyten, Schizomyceten und Schizophyceen, Myxomyceten, Flagellaten, Dinoflagellaten, Bacillariaceen und Conjugaten entstanden." This appears to propose that all these divisions arose independently from inorganic matter. A plant kingdom, including them, is then no more "natural" than a kingdom of the stones.

These various creatures do not disappear from the course in botany, just because they are not plants. To the extent that they are subjects of interest, this is still the most convenient place to become acquainted with them. Also, some knowledge of them is necessary for the understanding of real plants; just as one would begin with Chinese art and literature if his subject of study were Japanese civilization, and as the historian of a war must first picture its background. Anthoceros is not regarded as a fern, however important a knowledge of its life history is for the understanding of theirs.

The most of the differences between different texts and different courses are very unimportant. It is, however, very important that common sense, consistency, reasonableness, never be ignored. There is no other one thing so important in systematic biology as the fact that the grouping of organisms reflects and expresses their true relationships. It is inconsistent and unreasonable to begin the course in botany by doing violence to this basic principle.

Summary: The living things are not all plants or animals. Nature has been more resourceful, more thorough in trying out the possibilities. Another kingdom, that of the bacteria, using the word in an inexact sense, is likewise world-wide in distribution, probably most numerous in individuals and very important in its human relations. And, beside these three major kingdoms, there are a number of minor kingdoms, not unsuccessful, but much less successful lines of evolution from the primitive beginnings of life.

E. B. COPELAND

CHICO, CALIFORNIA

SCIENTIFIC EVENTS

THE NEW OXFORD SCHOOL OF PATHOLOGY

THE Sir William Dunn school of pathology at Oxford University, which has been three years building and has cost £70,000, was handed over on March 11 by the Sir William Dunn trustees, the directors of the Commercial Union Assurance Company, to the university. The opening ceremony was attended by many leading scientists, as well as by practically all the senior members of the university.

The new building will be under the direction of Professor Georges Dreyer, who has been professor of pathology at Oxford University since 1907. It has been designed to give the best modern facilities for teaching and research. In the old department there was somewhat inferior accommodation for about twenty-eight students. In the new building there is room for at least fifty, with every modern facility. Though by no means the largest, it is one of the best equipped institutions of its kind in the world. The old department could not house more than ten research workers, some of them with inadequate quarters. Here there is ample accommodation for twenty-five, and each is equipped with a large room, electric light and power and the latest appliances and fittings.

The general design of the building aims at simplicity. There are three corridors, one above the other, running the entire length of the building. Research will occupy the eastern and teaching the western wing, and at the rear there is modern accommodation for animals. The study of the effect of light and of X-rays on living matter, the chemistry research and the biochemistry research are each furnished with special apartments.

In the basement is a low-pressure chamber, which was designed during the war by Captain H. F. Pierce, now associate in physiology in Columbia University, built in the United States in 1917, and taken to France for testing air pilots. It was acquired by Professor Dreyer at the armistice from the American air force, and has since been used in a number of physiological experiments on the effect of altitude in producing mountain sickness and other disturbances and for other experiments. The school has on the ground floor an ample provision of space for the development of a fine departmental library.

Mr. C. D. Seligman, who made the presentation, said in part:

> The trustees felt strongly that it was far better, in the interests of mankind, to get at the primary causes of disease than to deal with disease when it had manifested itself. It was essential for this purpose that there should be a continued and sustained supply of men and women of the kind whose minds lent themselves to research, and what better place could they have for assembling such minds than the great seats of learning? While the Sir William Dunn Trustees had endowed a school of biochemistry at Cambridge and a school of pathology at Oxford, the Rockefeller trustees had endowed a school of biochemistry at Oxford and a school of pathology at Cambridge.

ACTS OF CONGRESS RELATING TO SCIENTIFIC WORK

FOLLOWING is a list of some of the acts of the last congress relating to scientific work:

H. R. 17138—Authorizing an appropriation of $50,000 to enable the secretary of agriculture to cooperate with the South Carolina Agricultural Experiment Station in investigating the dairying and livestock industries and the problems pertaining to the establishment and development of such industries, including cropping systems, soil improvement and farm-management studies related to such industries, and for demonstration, assistance and service in developing agriculture of the Sand Hill region of the Southeast. (Appropriation lost through failure of second deficiency bill.)

S. 1640—Authorizing the secretary of agriculture to establish and maintain a national arboretum on land within or adjacent to the District of Columbia for purposes of research and education concerning tree and plant life; authorizing the president to transfer to the jurisdiction of the secretary of agriculture by executive order any land now belonging to the United States located along the Anacostia River north of Benning Bridge, to be used for arboretum purposes; authorizing an appropriation of $300,000 for the purchase of additional land for arboretum purposes, with a restriction that the purchase price of any part of said land shall not exceed the full value assessment of such property last made before purchase thereof plus 25 per cent. of such assessed value; and authorizing the secretary of agriculture to create an advisory council in relation to the plan and development of the national arboretum to be established under this act, to include representatives of national organizations interested in the work of the arboretum. The act provides that the arboretum shall be administered separately from the agricultural, horticultural and forestry stations of the Department of Agriculture, but that it shall be so correlated with them as to bring about the most effective utilization of its facilities and discoveries. (Appropriation for land purchases lost through failure of second deficiency bill.)

S. 4153—Authorizing an appropriation of $820,000 for the acquisition of squares 576 and 578 in the District of Columbia as an addition to the United States Botanic Garden. (Appropriation lost through failure of second deficiency bill.)

S. 4910—Granting approximately 54,000 acres of public lands to the State of New Mexico for use of the New Mexico College of Agriculture and Mechanic Arts in conducting educational, demonstration and experimental work with livestock, grazing methods and range forage plants.

S. 5722—Authorizing an appropriation of $876,398 for the construction of new conservatories and other necessary buildings for the United States Botanic Garden.

S. J. Res. 120—Authorizing acceptance by the secretary of agriculture of a gift of about 1,760 acres of land in Teton County, Wyo., to be known as the Izaak Walton League Addition to the winter elk refuge maintained by the Biological Survey at Jackson Hole, Wyo., to be used for the grazing of, and as a refuge for, American elk and other big game animals.

MEETING OF THE NATIONAL ACADEMY OF SCIENCES

FOLLOWING is the program of scientific papers to be presented at the annual meeting of the National Academy of Sciences in Washington on April 25 and 26.

Monday, April 25, at 10:00 A. M.

FRANCIS G. BENEDICT and CORNELIA GOLAY BENEDICT: *The nature of the insensible perspiration.*

DOUGLAS H. CAMPBELL: *The embryology of Equisetum debile Roxb.*

W. J. V. OSTERHOUT: *Some aspects of protoplasmic surfaces.*

FLORENCE R. SABIN and CHARLES A. DOAN: *The effect of tubercle bacilli and the chemical fractions obtained from analysis on the cells of the connective tissues in rabbits.*

F. E. DENNY (introduced by John M. Coulter): *The effect of small amounts of chemicals in increasing the life activities of plants.*

A. V. HILL (by invitation): *The measurement of the heat production of nerve* (illustrated).

R. W. WOOD: *Physical, chemical and biological effects of high frequency sound-waves* (illustrated).

GEORGE A. BAITSELL (introduced by Ross G. Harrison): *Additional evidence as to the intercellular formation of connective tissue.*

April 25 at 2:00 P. M.

L. E. DICKSON: *Generalizations of Waring's problem on powers.*

R. A. MILLIKAN and I. S. BOWEN: *Relationships in the spectra of the elements of the first row of the periodic table* (illustrated).

F. E. WRIGHT: *The polarization of light by reflection from rough rock surfaces, with special reference to the material exposed at the moon's surface.*

WALTER S. ADAMS and ALFRED H. JOY: *High dispersion stellar spectra and some results of a study of γ Cygni.*

WALTER S. ADAMS and ALFRED H. JOY: *The relationship of spectral type to period among variable stars.*

F. K. RICHTMYER (introduced by J. S. Ames): *The variation of the adsorption of X-rays with wave length.*

K. T. COMPTON and P. M. MORSE: *Theory of the normal cathode fall.*

E. C. WATSON (introduced by R. A. Millikan): *Spacial distribution of the photo-electrons ejected by X-rays.*

CHARLES E. ST. JOHN: *Revision of Rowland's tables of solar spectrum wave lengths.*

DE THIERRY (by invitation): *Application of law of similitude to hydraulic laboratory research.*

DAYTON C. MILLER: *Report on ether drift experiments at Cleveland in 1927.*

C. G. ABBOT: *Periodicity in solar radiation.*

PAUL R. HEYL (introduced by G. K. Burgess): *A redetermination of the Newtonian constant of gravitation.*

EDWARD KASNER: *Differential invariants of irregular elements.*

Evening, at 8:30, in the Central Hall

FRANK B. JEWETT and HERBERT E. IVES: *Some recent advances in the art of distant electrical communication.*

Following this address, to which the members of the scientific societies of Washington are invited, the rooms adjacent to the Central Hall will be open for the inspection of the scientific exhibits.

April 26 at 9:30 A. M.

R. H. CHITTENDEN: *Biographical memoir of William Henry Brewer.* (To be read by title.)

EDWIN H. HALL: *Thermionic emission and the "universal constant" A.*

H. F. BLICHFELDT: *On the minimum values of positive quadratic forms.*

W. H. CREW and E. O. HULBURT (introduced by J. S. Ames): *Pressures in discharge tubes.*

FRANCIS B. SILSBEE (introduced by G. K. Burgess): *Current distribution in supra conductors.*

K. T. COMPTON and C. C. VAN VOORHIS: *Heats of condensation of positive ions and the mechanism of the mercury arc.*

W. A. NOYES: *Magnetic hydrogen atoms and non-magnetic hydrogen molecules.*

W. A. NOYES: *The relation of the octet of electrons to ionization.*

JOHN C. MERRIAM: *Exhibit of research results in the Grand Canyon.*

CHARLES W. GILMORE (introduced by John C. Merriam): *Footprints of unknown vertebrate animals in the Carboniferous and Permian of the Grand Canyon, Arizona.*

DAVID WHITE: *The age of the Hermit shale in the Grand Canyon, Arizona.*

CHESTER STOCK and RALPH W. CHANEY (introduced by John C. Merriam): *Fauna and flora of a new Pleistocene asphalt deposit near Santa Barbara.*

JOHN C. MERRIAM: *Significance of geologic range, or life period of animal species.*

NEIL M. JUDD (introduced by W. H. Holmes): *The architectural evolution of Pueblo Bonito.*

April 26 at 2:00 P. M.

D. F. HEWETT (introduced by David White): *Late Tertiary thrust faults in the Mojave Desert.*

ARTHUR L. DAY: *Boring for natural steam in California.*

ARTHUR L. DAY: *Recent volcanic activity in Japan.*

DOUGLAS JOHNSON (introduced by David White): *Sea-level surfaces and the problem of coastal subsidence.*

HARRY FIELDING REID: *The fundamentals of isostasy.*

SCIENTIFIC NOTES AND NEWS

DR. J. J. ABEL, professor of pharmacology at the Johns Hopkins University, will be presented with the Willard Gibbs medal at the second annual meeting of the Mid-West regional division of the American Chemical Society in Chicago on May 27 and 28.

DR. SIMON FLEXNER, director of the Rockefeller Institute for Medical Research, gave a series of three lectures on epidemiology under the Herter Foundation of the University and Bellevue Hospital Medical College, New York, on April 18, 20 and 22.

PROFESSOR JAMES W. JOBLING, of the Columbia University College of Physicians and Surgeons, was elected president of the American Association of Pathologists and Bacteriologists at the recent Rochester meeting.

AT the Richmond meeting of the American Chemical Society, Professor Richard Willstätter, until recently head of the department of chemistry at the University of Munich, now lecturing in the United States, was elected an honorary member. The society restored to honorary membership Dr. Wilhelm Ostwald and Dr. Walter Nernst, who had been dropped from the rolls during the war.

SIR FREDERICK GOWLAND HOPKINS, professor of biochemistry at the University of Cambridge, received from the University of Aberdeen, at the graduation ceremonies on March 23, the honorary degree of LL.D.

AT the June convocation of the University of Durham, the honorary degree of D.C.L. will be conferred upon Sir James Berry, president of the Royal Society of Medicine and consulting surgeon to the Royal Free Hospital.

DR. CHARLES F. JENKIN, professor of engineering at Oxford University, and Dr. A. C. Seward, professor of botany at the University of Cambridge, will receive honorary degrees from the University of Edinburgh at the graduation ceremony on June 1.

DR. JOHANNES THIENEMANN, director of the bird station at Rositten, has been elected a corresponding member of the American Ornithologists' Union and of the Danzig Society of Natural History.

PROFESSOR WILLIAM THALBITZER, Danish naturalist and Arctic explorer, has been awarded the Loubat prize of the Swedish Academy of Science.

THE council of the Geological Society of London has this year awarded the proceeds of the Daniel-Pidgeon Trust Fund to Mr. William Elgin Swinton, who proposed to undertake the comparison of British Mesozoic reptilia with those from similar deposits on the continent of Europe.

DR. ARTUR HANTZSCH, professor of chemistry at the University of Leipzig, celebrated his seventieth birthday on March 7.

DR. WALLACE W. ATWOOD, president of Clark University, has been presented with a diploma by the Institute of Technology of Breslau, Germany, conferring upon him the rank and rights of honorary senator. The testimonial said the diploma was given because of his distinguished work in development of economic geography and his efforts for the reestablishment of scientific relations between America and Germany.

MRS. CARL AKELEY, of New York, has been awarded the Royal Decoration of Honneur Extraordinaire by King Albert of Belgium for her work in completing the expedition of her late husband, Carl Akeley, into the Belgian Congo to get gorilla specimens for the American Museum of Natural History.

AT the meeting of the Alabama Academy of Science held in Birmingham on April 8 and 9 the following officers were elected for the year 1927–28: *President,* John R. Sampey, Howard College, Birmingham; *first vice-president,* John Y. Graham, University of Alabama; *second vice-president,* Harry F. Thomson, Birmingham; *secretary-treasurer,* James L. Brakefield, Howard College, Birmingham. The president appointed Dr. Wright A. Gardner, Alabama Polytechnic Institute, councilor to the American Association for the Advancement of Science.

DR. HOWARD A. EDSON, scientific and administrative head of the office of vegetable and forage diseases of the U. S. Bureau of Plant Industry, has been appointed chief examiner of the United States Civil Service Commission by President Coolidge. He succeeds Herbert A. Filer, who died recently.

DR. WILLIAM MONTGOMERY MCGOVERN, anthropologist and explorer, has been appointed assistant curator of South American ethnology in the Field Museum of Natural History, Chicago.

E. L. CHAPPELL has left the research laboratory of applied chemistry of the Massachusetts Institute of Technology to continue special studies on corrosion of water piping for the National Tube Company in the New York area.

DR. JOSEPH S. ILLICK has been appointed State Forester for Pennsylvania. For the last seven years he has been chief of information and director of research for the forestry department.

PROFESSOR LAURENCE M. GOULD, of the department of geology at the University of Michigan, has been named senior member and director of the George Palmer Putnam Expedition which will visit the Arctic regions this summer. The field work of the expedition will include extensive surveys in conjunction with a detailed mapping of the chief geographic characteristics of the area north of Baffin Island.

DR. N. L. BRITTON, director-in-chief of the New York Botanical Garden, has returned from a ten weeks' collecting trip in Porto Rico.

MRS. AGNES CHASE, associate botanist in the grass herbarium at the U. S. National Museum, sailed for Europe on March 26. She intends to visit Berlin, Paris, Geneva and Vienna, returning about June 15. The primary object of the trip is to study types of Paspalum in connection with a monograph of this grass genus now in preparation.

DR. GILBERT GROSVENOR, president of the National Geographical Society, sailed from New York on April 13, for a five weeks' visit to Spain and Morocco.

DR. HARLOW SHAPLEY, director of the Harvard College Observatory, gave a lecture entitled "Beyond the Milky Way" at Cornell University on March 12.

PROFESSOR WALDEMAR LINDGREN gave four lectures on mineral deposits, with especial reference to those of magmatic affiliations, at Queen's University on March 8, 9 and 10, under the auspices of the Willet G. Miller fund.

ON April 9, Professor J. H. Priestley, of the department of botany, University of Leeds, England, delivered an address to the Royal Canadian Institute on the subject "Light and the Growth of the Plant."

SIR JOHN RUSSELL, director of the Rothamsted Experiment Station, England, will lecture at the Wisconsin Agricultural Experiment Station in May.

DR. FRANCIS CUYLER VAN DYCK, emeritus professor of physics at Rutgers University, died on April 11, aged eighty-two years.

DR. DAVID HOUGH DOLLEY, professor of pathology in the school of medicine at St. Louis University, has died at the age of forty-eight years.

DR. JULIUS S. HORTVET, for twenty-seven years chief chemist of the Minnesota State Dairy and Food Department, has died, aged sixty-three years.

THE death is announced of Dr. D. MacEwan, emeritus professor of surgery in Univeristy College, University of Dundee.

ARTHUR BERNARD DEACON, a recent graduate in anthropology from the University of Cambridge, died on March 12 at Malecule, in the Hebrides, where he had gone on an anthropological expedition. Mr. Deacon was twenty-four years old.

PROFESSOR HERMANN WICHELHAUS, formerly head of the department of technology at the University of Berlin, has died, at the age of eighty-five years.

DR. GEORGE OSSIAN SARS, retired professor of zoology at the University of Oslo, well known for his work on oceanic zoology, died on April 10, at the age of ninety years.

THE American Electrochemical Society is to celebrate its silver jubilee at the coming spring meeting, to be held at the Hotel Benjamin Franklin, Philadelphia, on April 28, 29 and 30. Professor Edgar F. Smith, of the University of Pennsylvania, will preside at the session commemorating the founding of the society. Most of the charter members now living expect to attend the meeting. Interesting papers have been received describing the progress made in the past twenty-five years in the electric furnace, aluminum, cyanamid, chlorine and other industries. There will also be a review of the general progress in the entire field of electrochemistry. An outstanding feature of one of the meetings will be the address by Peter Debye, of the University of Zurich, on "The Dielectric Constant of Electrolyte Solutions." Professor Hugh S. Taylor, of Princeton University, will preside at this session.

THE Illinois State Academy of Science will hold its twentieth annual meeting on April 29 and 30 at Joliet, Illinois. The preliminary program contains a list of more than sixty papers to be presented before the various sections of the academy.

A JOINT meeting of the Wisconsin Academy of Sciences, Arts and Letters, the Wisconsin Archeological Society and the Midwest Museums Conference was held at the University of Wisconsin on April 7, 8 and 9. At the close of the meeting the following were elected to serve as officers of the Wisconsin Academy for a term of three years: *President,* Samuel A. Barrett; *vice-president* for sciences, Storrs B. Barrett; *vice-president* for arts, Arnold Dresden; *vice-president* for letters, E. K. J. Voss; *secretary-treasurer,* Chancey Juday.

THE *Journal* of the American Medical Association reports that the fourth International Military, Medical and Pharmaceutical Congress will be held at Warsaw, Poland, in May. About 3,000 delegates representing forty countries will participate, but the United States will not be represented officially because of the failure of Congress to pass the second deficiency appropriation bill; it will be represented unofficially by representatives of the U. S. Public Health Service who may be in the proximity of Warsaw at the time of the congress. A sanitary-hygienic exhibit will be held in connection with the congress, which will consist of sections on (1) military field sanitary equipment; (2) scientific hospital equipment; (3) sanitary equipment of dwellings; (4) chemical and pharmaceutic material; (5) physicians' and dentists' office equipment, and (6) veterinary equipment. Details may be obtained from the American commercial attaché, Aleja Ujazdowska 36, Warsaw, Poland.

THE Royal Photographic Society of Great Britain is holding its seventy-second annual exhibition in September and October of this year. This is said to be the most representative exhibition of photographic work in the world, and the section sent by American scientific men heretofore has sufficiently demonstrated the place held by this country in applied photography. It is hoped that the scientific section will be well represented in 1927, and, in order to enable this to be done, with as little difficulty as possible, A. J. Newton, of the Eastman Kodak Company, Rochester, N. Y., has arranged to collect and forward American work intended for the scientific section. This work should consist of prints showing the use of photography for scientific purposes and its application to spectroscopy, astronomy, radiography, biology, etc. Photographs should be received not later than June 11.

THE Massachusetts Institute of Technology announces ten research fellowships of $1,000 each for the year 1927–28, open to graduate students who desire to undertake the investigation of fundamental problems in the field of automotive engineering. Applicants for these fellowships must present evidence, not only of high scholastic standing, but also ability to carry on research. Further information regarding these fellowships may be obtained from Professor H. M. Goodwin, dean of graduate students, Massachusetts Institute of Technology, Cambridge.

IN cooperation with the Pittsburgh Experiment Station of the United States Bureau of Mines, eight research fellowships in mining and metallurgy are offered by the Carnegie Institute of Technology for the coming year. The fellowships are open to graduates of colleges, universities and technical schools who are properly qualified to undertake research investigations. Each fellowship carries a stipend of $750. The purpose is the solution of problems which are of special importance to the mining, metallurgical and allied industries. Several of the fellowships will be financed by industrial groups or corporations.

SECRETARY JARDINE has reappointed as members of the Northeastern Forest Research Council, for a period of four years, Professor R. S. Hosmer, of Cornell University, and Dr. J. C. Kendall, of the New Hampshire Agricultural Experiment Station. He has also appointed S. H. Thomson, president of the Federal Land Bank, of Springfield, Mass., in place of C. H. Keith, of the New England Box Company, and

Blaine S. Viles, state forest commissioner of Maine, in place of F. H. Colby, of the Kennebec Valley Protective Association. The place left vacant by the resignation of H. G. Philbrook, of the Vermont Timberland Owners' Association, has not yet been filled. This council was created to encourage and coordinate research in forestry by all appropriate agencies in the Northeast, including the Northeastern Forest Experiment Station, which functions as a part of the Forest Service.

ACCORDING to information given out by the health section of the League of Nations and reported by the Berlin correspondent of the *Journal* of the American Medical Association, four Japanese medical men will be sent next year to Europe for a stay of nine months. Their specialties are prophylaxis of infectious diseases, the science of nutrition, diseases of the reproductive organs and insurance legislation. Four medical men will likewise be sent from Europe to Japan for nine months, and will be admitted to the Imperial Japanese Institute for Infectious Diseases, the Kitasato Institute and the Hygienic Institute and the Institute for the Science of Nutrition, at the University of Tokyo.

THE American Society of Mechanical Engineers has accepted custody of $17,500 given by the Lincoln Electric Company of Cleveland, to be awarded to those contributing the best three papers disclosing new information that will tend to advance the art of arc welding. For the best paper $10,000 will be awarded; second prize is $5,000 and third prize $2,500. The purpose of the competition is to encourage improvements in the art of arc welding, the pointing out of new and wider applications of the process or indicating advantages and economies to be gained by its use.

DR. CHAS. N. GOULD, director of the Oklahoma Geological Survey, announces that Governor Henry S. Johnston has signed the bill appropriating funds for the work of the survey during the coming biennial. The amount provided is $45,000 per year. Plans are being consummated to put several parties in the field during the coming summer and to issue reports on the work accomplished. These plans contemplate studies of the Simpson formation of the Arbuckle Mountains, which contains the "Wilcox" oil sand, by Charles E. Decker; a study on the zinc fields of Ottawa County by Samuel Wiedman; studies of the Cretaceous of Western Oklahoma by Fred M. Bullard; studies of the Woodford-Sycamore-Caney beds of Mississippian and Pennsylvanian age in the Arbuckle and Ouachita Mountains by C. L. Cooper; a study of the asphalt of the state carried on in cooperation with the experiment station of the U. S. Bureau of Mines at Bartlesville; and a study of road materials in cooperation with the State Highway Commission. During the past two years reports aggregating over three million pages have been issued by the Oklahoma Geological Survey.

A PROCLAMATION by President Coolidge enlarging the boundaries of the Superior natural forest in Minnesota to include approximately 386,600 acres, which are ultimately to be added to that reserve, has been made public by the forest service of the U. S. Department of Agriculture. The executive order brings the total area held by the government in the Superior reserve for restocking with native timber, in accordance with the forestry services lakes states reforestation program, to 1,186,761 acres. The Minnesota national forest, another project, includes 190,000 acres, and the Tawas national forest, in the northern part of the lower peninsular of Michigan, comprises 126,762 acres.

DR. WILLIAM SCHAUS, specialist in Lepidoptera in the U. S. Bureau of Entomology, recently donated to the National Museum a valuable collection of 10,000 specimens of moths, most of them from Bolivia, which were purchased by him from a collector of that country.

AN entomological survey of the Pacific, financed by private funds, is being organized in Honolulu. On the directing committee are Dr. C. Montague Cooke, *chairman,* Charles R. Hemenway, Dr. Arthur L. Dean and Charles S. Judd.

THE John Borden-Field Museum expedition to the Arctic will sail from San Francisco on April 23, in the *Northern Light,* a vessel specially constructed for Mr. Borden a few months ago. Several members of the party will be taken aboard at Victoria, British Columbia, from whence the vessel will proceed northward through the inside passage between the islands and the mainland, to the extreme western end of the Alaskan peninsula. The latter part of July the expedition will enter the Arctic Ocean, where it will remain for about two months.

THE University of Rochester is making plans for a teaching museum of natural history to be included in its new plant on Oak Hill. The new museum is planned to cover geology and biology, and will consist of two floors, each about eighty feet square. Construction of the exhibits has begun. One of the wall models now completed depicts Allen's Creek flowing through a glen about five miles east of Rochester. A second model will show Irondequoit Bay and preliminary studies are under way for a third model to show the evolution of the horse.

DINOSAUR HALL, said to contain the finest collection of prehistoric reptilian remains in the world, was opened formally on March 9 at the American Museum of Natural History. The hall is on the fourth floor of the new southeast wing of the museum, built with a $1,500,000 appropriation made by the city during Mayor Hylan's administration.

FIVE hundred specimens of mammals, reptiles, frogs, birds, fishes and insects have been received by the Field Museum from the Field Museum-Conover-Everard expedition to Central Africa, according to an announcement by D. C. Davies, director of the museum. The expedition was financed jointly by H. B. Conover, associate in ornithology at the museum, and Robert T. Everard, Detroit sportsman. They were accompanied by John T. Zimmer, assistant curator of birds at the museum. Leaving Chicago last April the party spent approximately eight months collecting in Central Africa.

AN outdoor museum, which will display under natural conditions examples of every tree, shrub and herb found growing in the Harriman State Park, New York, and a menagerie, showing in natural environments all the animals native to the Hudson Highlands region, will be developed at Bear Mountain in the park. Announcement to this effect was made on February 21 by the commissioners of the Palisades Interstate Park, which will carry out the plan in cooperation with Henry Fairfield Osborn, president of the American Museum of Natural History. The museum will be built with funds granted by the Laura Spelman Rockefeller Memorial at the request of the committee on outdoor education of the American Association of Museums, of which Chauncey J. Hamlin, of Buffalo, is chairman. The cost of the building will be about $7,500.

DURING the past two years the Oklahoma Geological Survey, under the direction of Chas. N. Gould, has held a series of field conferences in Oklahoma and adjacent states, for the purpose of studying and correlating the different geological formations of the region. While these conferences are held primarily for geologists, the interested public is welcome. More than 200 geologists have participated in these various conferences. Two other conferences are scheduled for the coming months. On March 28 and 29, following the annual meeting of the American Association of Petroleum Geologists at Tulsa, there will be a conference in the Arbuckle Mountains and the Ardmore Basin. Among the points of interest to be visited will be the porphyry monadnock known as East Timbered Hills, Turner Falls, Price's Falls, the asphalt mines, White Mound, Burning Mountain, Caddo Anticline and Criner Hills. Later in the season, probably in May, it is planned to hold a field conference in the Panhandle of Oklahoma, studying conditions near the Ramsey well in Cimarron County, together with the volcanic rock on Black Mesa and the various Cretaceous exposures in that area.

THE cancer commission of Harvard University and the Collis P. Huntington Memorial Hospital have received contributions amounting to $34,619 for the cancer fund.

UNIVERSITY AND EDUCATIONAL NOTES

ILLINOIS WOMAN'S COLLEGE, Jacksonville, Illinois, is to have a new science hall which will cost about $200,000. It will be a three-story brick and stone building of the Georgian type of architecture and will contain laboratories and classrooms for the departments of chemistry, physics and biology. It will be ready for occupancy next fall.

WORK is to start about June 1 on the new $300,000 science building which Milwaukee-Downer College will build to house the departments of zoology, botany, physics, geology, geography and domestic science.

THE construction of a new three-story $600,000 building for the Philadelphia College of Pharmacy and Science will be undertaken at once. The board of trustees of the college has decided to reduce the number of freshman students for the next session to 250, in the interests of better education.

THE Neurological Institute of New York City has received a gift of $200,000 from Mr. William Bingham, of New York and Cleveland. The gift is to be used to build and equip one floor in the new building of the institute to be constructed in connection with the new Columbia-Presbyterian medical center, and is given as a memorial to Dr. J. G. Gehring, neurologist, of Bethel, Me.

CHANCELLOR TRYGGER, of Upsala University, has announced that the institution will celebrate its 450th anniversary from September 15 to 17. University representatives in all parts of Europe will be invited to attend. Upsala University was founded in 1477 by Jakob Ulfson.

DR. KIRTLEY F. MATHER, associate professor of physiography at Harvard University, has been promoted to be professor of geology.

RUTGERS UNIVERSITY has promoted Dr. Leon A. Hausman, from assistant professor of zoology to associate professor; Dr. Clyde M. Huber, from instructor to assistant professor of mathematics, and Dr. Darrell B. Lucas, from instructor to assistant professor of agricultural engineering. George W. Musgrave, professor of agronomy, has resigned.

IN the school of medicine at Stanford University, Dr. George D. Barnett, Dr. W. Edward Chamberlain and Dr. Henry G. Mehrtens have been promoted to full professorships in the department of medicine. In the same university Dr. Maurice L. Tainter has been promoted to an assistant professorship of pharmacology.

DR. HULSEY CASON has been appointed assistant professor of psychology at the University of Rochester.

J. W. BARKER has resigned his position as professor of chemistry in the Junior College of Flat River, Mo., to fill an assistant professorship in the chemistry department of Wittenberg College.

PROFESSOR W. W. C. TOPLEY has resigned from the chair of bacteriology and the directorship of the public health laboratory at the University of Manchester, as from September next, when he will take up his duties as professor of bacteriology and immunology in the new London School of Hygiene and Tropical Medicine.

THE chair of mineralogy and geology at the University of Lille has been changed to a chair of geology and physical geography and M. Leriche has been appointed to the position.

DISCUSSION AND CORRESPONDENCE

THE LUNAR ECLIPSES OF 1927

THERE are to be two lunar eclipses in 1927, about the middle and end of the year. Some of their relations to the earth's atmosphere are as follows:

1927 June 15, the first eclipse is at its height (mid-eclipse) at 8 h 24.2 m, Universal Time; but the moon barely gets within the umbra on the north side of the earth's shadow. The radius of the geometrical umbra is 40.8′; the outer limb of the moon at mid-eclipse is distant 40.7′ from mid-shadow. At this moment the edge of the shadow nearest to the moon's limb is cast by the earth's surface and atmosphere at about W 97.3°, N 63.75°, in the neighborhood of Baker Lake, which drains into Chesterfield Inlet, on the west shore of Hudson Bay. It would be very interesting to know the weather, cloud and sky conditions in this region at this moment. But the atlas indicates hardly any population there.

In the eclipse of 1892 November 4 the outer limb of the moon was 43.0′ from mid-shadow, the radius of the geometrical umbra was 45.4′, so that the immersion was deeper than in the coming case. But Gale, at Sydney, N. S. W., reported the limb so bright as to give the impression that the eclipse was not total; Russell, also at Sydney, said definitely that it was not total; Doberck, at Hong Kong, remarked on the brilliancy of the immersed limb. We may expect this time to observe the density of the earth's shadow very near to the edge, but due to weather and climate conditions very different from those which ruled in 1892. Then the grazing point was over water, between Iceland and Norway, north of the Shetland Islands.

The last rays on the moon's limb at first contact with the umbra graze the earth's surface or atmosphere about W 174.7°, N 32.7°. This is at sunset on the open Pacific, north of Pearl and Hermes. The rays at last contact in like manner graze about W 69.1°, N 17.6°, a point at sunrise in the Caribbean Sea, considerably south of Catalina Island, south of Santo Domingo. Observations of weather, cloud and sky at these points are desired, for comparison with direct observations of the shadow edge at these moments.

The two internal contacts at this eclipse come so close together that they are hardly separable from mid-eclipse. At mid-eclipse the sunrise-sunset line, centered about the subsolar point at E 54.0°, N 23.3°, passes by Cape San Roque, Nova Scotia, Great Bear Lake, New Guinea, Gulf of Carpentaria and Enderby Land. Of all this great circle, however, only a fraction, perhaps 35°, on the two sides of the Baker Lake region, is effective in illuminating the eclipsed moon.

The second lunar eclipse, on December 8, with middle at 17 h 34.6 m, Universal Time, is of much deeper immersion, 11′ or more at most, in the southern half of the shadow. The inner (north) limb of the moon just covers the middle of the shadow. The grazing light at the contacts comes from regions about the points indicated:

First Contact: E 41.6°, S 25.7°, in the Mozambique Channel, between Tullear and Europa Island, at sunset.

Second Contact: E 51.0°, S 51.3°, in the Sea Tang, south of the Crozets, at sunset.

Third Contact: E 164.4°, S 22.0°, southwest of New Caledonia, at sunrise.

Fourth Contact: E 157.0°, S 3.5°, northeast of Bougainville Island, at sunrise.

Observations of weather, cloud and sky at these points are desired, for comparison with observations of the shadow edge at the contacts.

At mid-eclipse the sunrise-sunset line is centered about the subsolar point at W 85.75°, S 22.7°, and passes over or near Kaiser Wilhelm Land, Fiji Islands, Sitka, Timbuctoo, Mossamedes, Cape Town. The whole southern half of this great circle is effective in illuminating the eclipsed moon at this moment.

The mere naming of the grazing points above indicates that observations within a few degrees of them are unlikely to be obtained. Still, it is desired that persons near any such, at sea or ashore, report

their observations of weather, cloud and sky, at the sunrise or sunset moments indicated, either to some scientific journal or to the address, Lunar Eclipses, Harvard College Observatory, Cambridge, Mass., U. S. A.

WILLARD J. FISHER
HARVARD COLLEGE OBSERVATORY

RESEARCH ON VIRUSES CAUSING PLANT DISEASES

BECAUSE of failure to determine the nature of filterable viruses by microscopic or culture methods, plant pathologists have for some time been attempting to obtain less direct evidence on the nature of these disease-causing agents by studying their resistance to various treatments, such as desiccation and exposure to chemicals. The results of such studies are very valuable but are often difficult to interpret, because the virus, as heretofore studied, has been contained in a complex medium, the host plant extract.

It is well known that the properties of colloids may be greatly modified by the addition of certain substances. For example, Mines[1] has shown that the addition of certain protective proteins to colloidal gold may cause the latter to exhibit properties characteristic of proteins. Similarly, it appears possible that protective colloids, as well as other factors in the complex plant extract, may so modify the properties of a virus as to give an erroneous impression of its real nature.

The marked resistance of some of the viruses to toxic chemicals suggests the possibility that such viruses may remain infective after various purification treatments and may therefore be obtained in a fair degree of purity. The properties of such purified or partly purified virus should be more reliable as an indication of its nature than properties exhibited by a virus contained in complex plant extract.

A study of the literature on viruses and enzymes has suggested the possibility that the operations recently used by Sherman, Caldwell and Adams[2] and others in attempting to isolate enzymes may be successfully used in similar attempts to purify viruses. Among the operations which may be useful in such work are selective adsorption, treatment with microorganisms, precipitation, cataphoresis, centrifugation, sedimentation and dialysis.

While numerous studies on virus properties such as longevity, resistance to drying and chemicals, and inactivation by certain plant juices have been made, it appears that the available evidence, although very valuable, is insufficient to warrant conclusions as to the animate or inanimate nature of the viruses. Other similar experiments which appear promising for furnishing further evidence on this question are listed below.

(1) Since the protozoa appear to be particularly susceptible to high oxygen concentrations, Cleveland[3] has suggested that evidence on the nature of the viruses might be obtained by subjecting them to oxygen treatments. The influence of the absence of oxygen should also be very interesting.

(2) Test viruses for tropisms.

(3) Cataphoresis of a virus at various hydrogen-ion concentrations and before and after treatment with other ions.

(4) Attempt to inactivate a virus by mixing it with colloids of known composition. If inactivation is successful attempt to reactivate the virus by methods similar to that used by Johnson-Blohm[4] in reactivating rennet. These methods may also be useful in reactivating a virus which has been inactivated by certain plant juices.

(5) Attempt to separate the causal agent into several components by dialysis or other separation methods.

(6) Test host tissues for compounds often produced by microorganisms.

(7) Attempt to detect respiration in the viruses.

T. E. RAWLINS
PLANT PATHOLOGY DIVISION,
UNIVERSITY OF CALIFORNIA

NATIVE AMERICAN APPLES

THE indigenous apples of America form an interesting group of species that have been neglected because the cultivated apple, Pyrus Malus, with better and larger fruit, came from Europe more than three centuries ago. However, a few trees with large fruits have been found among wild American apples. During many years the writer has made a study of these large-fruited sports found in the woods of our western states, especially Iowa, Illinois, Missouri, Wisconsin and Minnesota. Many hybrids have been originated at the South Dakota Experiment Station, and it is now time to publish some of this material. I would like information concerning any large-fruited trees of the wild American apple, with specimens of the fruit and notes as to the history and location of the trees. Please help in this search so that a list may be published for future use.

N. E. HANSEN
SOUTH DAKOTA STATE COLLEGE,
BROOKINGS, SOUTH DAKOTA

[1] *Koll. Chem. Beihefte*, 3: 191–236, 1912.
[2] *Jour. Amer. Chem. Soc.*, 48: 2947–2956, 1926.
[3] SCIENCE, n. s., LXIII: 168–170, 1926.
[4] *Zs. Physiol. Chem.*, 82: 178–208, 1912.

BIOLOGY AT THE UNIVERSITY OF MAINE

IN view of the importance of questions of academic tenure and of administrative attitude toward teaching and research, recent events at the University of Maine concerning the department of biology may be of interest. On November 23, 1926, Associate Professor Alvalyn E. Woodward and I were dismissed with no charges of neglect of duty, inefficiency or misconduct. When the administration objected to the display of the letters of dismissal to numerous biologists it was asked for a full statement of the true causes of dismissal. No reasons were given with reference to Dr. Woodward, and she has since been reinstated. With reference to my own case the correspondence printed below is self-explanatory.

On account of the plans of the administration for the second semester of the present year, an instructor and a full-time assistant resigned and left at the close of the first semester. The professor of botany has likewise resigned and it appears that the department will be entirely reorganized for the coming year.

P. W. WHITING

BUSSEY INSTITUTION

November 23, 1926

College of Arts and Sciences
Dean's Office
DR. P. W. WHITING,
Campus

Dear Dr. Whiting:

After consultation with the president of the university it has been decided that the department of biology is not efficiently organized for carrying on the necessary work here. As you know, Dr. Little had visions of a strong research department and you and others were brought here with that end in view. While we expect to emphasize research work to a considerable extent we feel that we can not give it the predominance which Dr. Little expected. We are, therefore, planning to reduce the staff somewhat, and this letter is to inform you that the chair which you now hold will be discontinued at the close of the academic year. I wish to make it perfectly clear to you that your scholarship and ability as a biologist are highly appreciated and that your going is a result of a situation which has arisen rather than from any criticism which we have to make upon your work. Both President Boardman and myself will be glad to make this situation clear to the department officials of any institution where you may care to seek a position.

Very truly yours,
(*Signed*) JAMES S. STEVENS.

January 18, 1927

The President
PROFESSOR P. W. WHITING,
Campus

Dear Professor Whiting:

Replying to your letter of the eighth instant, in which you suggest that I give you further information regarding our request that you sever your connection with the institution, I am giving you the following statement.

During the year and a half in which I have been in a position to judge, the department of biology has not functioned properly under your direction. It is not necessary for me to cite instances or discuss reasons. It is sufficient to say that the department has not shown signs of any recovery and a reorganization is necessary. It does not appear that you are primarily interested in the administration of a department, especially of one which from its position must render all the different kinds of service which in this institution we are obligated to give. The head of the department must in addition to other qualifications be able to guide it with a firm hand and so correlate its activities that it will render efficient service in *all* of its objectives. This you have not done, and this fact, together with your own statements, in which you have shown that your chief interest lies along other lines, show that you do not fit the position you now hold. That this is not against you as a scholar or a biologist is conceded, and the letter written by Dean Stevens, which evidently created a misunderstanding, attempted to make that clear without going into further details.

Permit me to say that it is far from the truth that you are severing your connection with this institution because you are a research man. It is because you lack additional qualifications which are vitally necessary for the head of any department. Whether this lack is due to inability or to lack of interest does not enter the discussion.

For your information I will say that it is my intention to foster the research work of the department of biology. I should not consider that the department could flourish without it. It is also my intention to see that a strong teaching department is developed so that the demands made upon it from all sources may be met.

Very truly yours,
(*Signed*) H. S. BOARDMAN,
President

February 1, 1927

PRESIDENT H. S. BOARDMAN,
Campus

Dear President Boardman:

Your letter of January eighteenth has been received. I assure you that, in accordance with your wishes, I shall take means to bring this letter to the attention of numerous biologists and to any who may be interested in affairs at Maine.

It is evident that my method of running a department is very different from that of which you approve. My policy is to have responsible members only, dismissing the irresponsible The "firm-hand" policy with all its time-wasting watchfulness would not then be necessary. It is well known that the latter method has recently been employed in another department with the approval of the administration and with results not conducive to the best type of scholarship.

I can not admit any lack of attention to management of the department or to details connected with teaching. Moreover, it should be recognized that, in addition to my

own efforts, Mrs. Whiting has devoted considerable time and attention in preparation of material for courses and in instructing individual students, thus relieving other members of the department.

My "Program for Teaching and Research in Biological Science at the University of Maine," which was submitted to you after President Little's departure, was worked out with much care and approved by several eminent biologists at the university. It was, however, negatived by the administration in points essential both to efficient teaching and to research, despite the fact that the present budget allowance was ample to cover all expenses involved.

I assure you that I am leaving Maine with no feeling of resentment, but with the hope that a more constructive policy will be pursued in the future.

Very truly yours,

(*Signed*) P. W. WHITING

SCIENTIFIC BOOKS

Textbook of Comparative Physiology. By CHARLES GARDNER ROGERS. McGraw-Hill Book Co., New York. 1927. List price, $5.50.

To state that Professor Rogers's book is new and different from others tells little; yet even this feeble remark may attract attention to the work among the books of the year. The present writer is not a physiologist, but he feels moved to say something about the book for the benefit of his non-physiological brethren. Professional physiologists will soon be familiar with it; zoologists and botanists working in other fields need to have it brought to their notice.

A few of the chapter headings may be listed: II. Solutions, III. Diffusions and Osmosis, V. Properties of Protoplasm, VII. General Phenomena of Life, X. Blood as an Oxygen Carrier, XIII. Circulatory Mechanisms, XVIII. Catalytic Actions of Animals, XXII. Nutrition of Different Animal Groups, XXVI. Physiology of Movement. These rather familiar titles, most of which are found in all physiologies, suggest the general scope of the work and yet they do not give any intimation of the freshness of treatment and the breadth of outlook which our author brings to us. In his hands, physiology becomes functional biology, the real science of life.

Dr. Rogers compassionately spares us the multitude of algebraic formulae and soul-corrupting graphs now so popular. He is teaching physiology, not mathematics, physics and chemistry. He gives clear pictures of life processes in general and offers a wealth of information about the physiology of invertebrates not obtainable in our usual books of reference. He presents his material in logical and interesting form with no apparent bias for pet theories. If an outsider might presume a suggestion, it would be that in future editions the introductory part to each chapter be somewhat amplified or that a rather "popular" summary be placed at the close of each chapter.

Every young zoologist and botanist (and some of the older ones, too) could profit by knowing the book and making use of it.

FRANCIS RAMALEY

UNIVERSITY OF COLORADO

Ice Ages, Recent and Ancient. By A. P. COLEMAN. New York: The Macmillan Co., 1926. pp. 296, 51 figs., 8 maps.

IT is the stroke of the master pen. Only mastery could produce so complete, frank, simple and obviously trustworthy an account of the Ice Ages of the earth. Many accounts of personal experience enliven the style of the book. As an introduction to the work of ancient glaciers, the activities of living glaciers are sketched with a few well-chosen examples. The Pleistocene glaciation is treated only briefly, since "the work is not intended to take up the Pleistocene in great detail, but rather to outline its extent, to describe its mode of operation and to study particularly such features as will throw light on more ancient and therefore less completely recorded glaciations." The drift, the extent, the centers of radiation and the interglacial periods are discussed both for North America and abroad. One interesting point in North America is that the Cordilleran sheet was formed first and was followed in succession by the Keewatin and then the Labradorian sheets. It is inferred by the reviewer that this applies to the last of the Pleistocene sheets. It would be of great interest to know whether this succession holds for the earlier of the Pleistocene invasions. Doubtless data are not available to answer this question, for the author makes no mention of it. Four interglacial periods are recognized near the drift-margin in North America, while at least one is distinguished in Canada near Toronto and Moose River. Likewise three warm interglacial periods are accepted in the Alps and in Denmark, while studies of the interglacial climates have led to the conclusion that the ice in Europe, as well as in North America, was completely removed at least once during the Pleistocene.

Ancient ice ages are beautifully described. Eocene and Jurassic tillites in North America are discussed. In all the periods of the Paleozoic era, glaciation is either strongly inferred or is proved. Of these the world-wide Permo-Carboniferous glaciation, the greatest in the history of the earth, receives its due consideration. Chapters on the Talchir tillite of India, the Dwyka of South Africa, the Squantum of North America and the tillites and interglacial deposits of

South America and Australia are very impressive. They leave no doubt in the reader's mind of the magnitude and certainty of the refrigeration. Continental ice sheets of Silurian age are known in Alaska. The Varanger Fiord tillites of northern Norway have been recently correlated with the Ordovician. Widespread Ordovician glacial conglomerate is also recognized in Gaspé. Early Cambrian or late pre-Cambrian tillites are described from the Yangtzi Canyon in China, from southern Norway, from several places in North America, from Africa and from Australia, placing this ice age as equal in magnitude to that of the Pleistocene.

The widespread Gowganda tillite of Huronian age in Canada is convincingly described as of glacial origin. And beds of similar age, probably of glacial origin, are cited from several other parts of the world. Conglomerates strikingly like tillites are discussed from the Timiskamian and Keewatin rocks of Canada, though metamorphism has rendered their sure reference to glacial origin uncertain.

The effects of glacial periods on both plants and animals, treated rather fully, makes a very suggestive contribution to the study of organic evolution.

Defects in all existing theories of the cause of ice ages are pointed out. But the author confesses he is unable to propose something better. In his opinion the solution must come from general and local causes in a combination of astronomic, geologic and atmospheric conditions.

Photographs are numerous and in general very good, though many of them lack a scale. The book is of great importance not only to the glacial geologist, but to the historical geologist, the paleontologist and the paleobotanist as well.

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SPECIAL ARTICLES

THE NATURE OF THE "INORGANIC PHOSPHATE" IN VOLUNTARY MUSCLE

SOME months ago we[1] described a colorimetric phosphate method, the special feature of which is the use of a very active agent (aminonaphtholsulfonic acid) for converting the phosphomolybdic acid to its blue reduction product. When we first made use of this method for the determination of inorganic phosphate in protein-free muscle filtrates, shortly after the details had been worked out, we found a marked delay in color production. The time required to reach a constant reading was about thirty minutes, whereas ordinarily the full color (relative to the standard) has developed within four minutes or less. This peculiar behavior appeared to indicate that muscle contains either some substance capable of retarding the color reaction or else a very unstable (presumably organic) compound which liberates o-phosphoric acid while the color is developing. While the course of the color development in muscle filtrates turned out to be quite different from anything which we had seen in testing out the method in the presence of known interfering substances, it is impossible to rely on this point as a means of distinguishing between the two alternatives. Ferric salts, for example, also behave in a way that is unique. A mixture of inorganic phosphate and ferric chloride certainly does not contain a highly unstable organic phosphorus compound, and the delayed color reaction found with muscle filtrates therefore does not constitute conclusive proof of the existence of such a substance in the muscles.

Further study of the course of color development nevertheless did bring out some interesting and suggestive points, notably the fact that the delay is hardly any more pronounced with 10 cc of muscle filtrate, for example, than with 5 cc or less. Every interfering substance which we investigated in the course of our work on the phosphate method, on the other hand, shows a much more marked effect when the phosphorus content of the sample is increased. Although these facts have been in our possession now for more than a year, we have until this time refrained from placing them on record, inasmuch as the phenomena observed could not with any certainty be ascribed to the presence of an organic compound of phosphoric acid until the compound had been isolated, or at least until the organic radicle had been identified. Both these things have now been done, although the isolated substance has not yet been obtained in the pure state, and the outcome appears likely to throw light on a field of biochemistry never before suspected of being in any way related to phosphoric acid.

Muscle filtrates from which all the inorganic phosphate has been removed (by precipitation with barium, silver, etc.), as well as material which has been still further purified, show the same delay in the production of the color. These facts, together with the knowledge that the delayed reaction really is associated with the hydrolysis of an organic compound of phosphoric acid, give real significance to the quantitative data which we have meanwhile been accumulating. Some of these data will now be presented before we proceed to a discussion of the nature of the substance.

The method which we have used for the determination of this unstable form of phosphorus (which we shall for the present designate as "labile phosphorus")

[1] C. H. Fiske and Y. Subbarow, *J. Biol. Chem.*, Vol. 66 (375)—1925.

differs in no respect from our regular phosphate method, except that readings are taken at brief intervals (every minute, beginning with the third, until the unstable substance is about half hydrolyzed, and thereafter every few minutes until no further change occurs). The growth in color intensity for the first few minutes is practically linear, and the concentration of inorganic phosphate is found by extrapolating back to zero time. The sum of the inorganic and the "labile" phosphorus is calculated from the final reading, and the amount of "labile phosphorus" found by difference. From control analyses of solutions of the purified organic compound, with and without the addition of known amounts of inorganic phosphate, we believe that the results are accurate within 1 or 2 mg of phosphorus per 100 gm of muscle.

The principal results which we have obtained by this method of analysis are as follows: (1) The normal resting voluntary muscle of the cat shows generally about 60 to 75 mg of "labile phosphorus" per 100 gm if removed with the greatest possible care and at once cooled to 0° C. or below. (The further preparation of the material for analysis consists simply in precipitating the protein with ice-cold trichloroacetic acid, filtering and immediately neutralizing the filtrate with sodium hydroxide.) The true inorganic phosphorus under these conditions is only 20 to 25 mg, instead of the 80 to 100 mg, shown by other methods of analysis. (2) After prolonged electrical stimulation, the "labile phosphorus" usually falls to about 20 mg (in one instance to as little as 9 mg), while the inorganic phosphorus is correspondingly increased. (3) Stimulation with the blood supply shut off, in which case complete fatigue ensues, causes complete disappearance of the unstable compound, within the error of analysis. Merely shutting off the circulation for an equal length of time has little or no effect. (4) A period of rest after the muscle has been stimulated is accompanied by resynthesis of the organic compound. The maximum yield of "labile phosphorus" so far observed under these conditions is 46 mg per 100 gm of muscle. The inorganic phosphate, however, falls to the normal level, so in all probability either some of the phosphate has been discharged into the circulation, or else the water content of the muscle has increased.

The compound under consideration is a derivative of creatine. On a small scale we have succeeded in separating it from all other phosphoric acid compounds. On a sufficiently large scale to yield material enough for a complete analysis, the separation is not so readily accomplished by our present methods, and the best products that we have so far procured contain several per cent. of one or more other phosphorus compounds, since the full blue color can not be obtained unless the material is ashed. In spite of this contamination, the phosphate, creatine and base in two salts which have been prepared add up to about 85 per cent. of the weight of the entire substance, indicating the probable absence of a third component. The elementary analysis of amorphous products, unless they are of definitely established purity, proves very little. Our main evidence for the existence of "phosphocreatine" in muscle is of a quite different nature. In the first place, we have found that the "labile phosphorus" can be more or less completely separated by precipitation with a number of different reagents (six in all have been used to date), and that in each case there is precipitated with it one equivalent of creatine. One of these reagents (copper in slightly alkaline solution) has been applied to muscle filtrates prepared under various conditions, and the proportionality between creatine and "labile phosphorus" has never failed. A few typical illustrations of our experience with copper precipitation are given in the accompanying table. They serve to show that creatine and the labile form of phosphate are precipitated together, in equivalent proportions, whether the muscle was fresh and in the resting state or whether it had been subjected to manipulations which alter the concentration of the "labile phos-

	Mg per 100 gm muscle		
	"Labile phosphorus"	Creatine in washed copper precipitate	Molecular ratio of creatine to phosphoric acid
Normal resting muscle	70	280	0.95
do	77	323	0.99
Normal resting muscle:			
(1) Fresh	65	269	0.98
(2) Stood few minutes after removal from body	55	222	0.96
(3) Stood for longer time	32	128	0.95
(4) Analysis of trichloroacetic acid filtrate (from fresh muscle) which had stood for several hours	0	2	
Muscle stimulated for 10 minutes with circulation intact	20	82	0.97
Muscle stimulated to fatigue with blood supply shut off, followed by 1 hour rest period	44	192	1.03

phorus." Thus, when the muscle is allowed to stand outside the body, the "labile phosphorus" content progressively diminishes at a fairly rapid rate (it is entirely gone in less than twenty minutes), and at the same rate creatine is set free, as indicated by its failure to be thrown down by copper. If the trichloroacetic acid filtrate prepared from a sample of fresh muscle is kept (unneutralized) for several hours, the "labile phosphorus" has completely disappeared, and the copper precipitate is then virtually free from creatine. The same parallelism holds for muscle which has been stimulated, showing that the liberation of inorganic phosphate during stimulation is associated with the conversion of the creatine to a form in which copper will not precipitate it. Finally, in case the muscle has been stimulated with the blood supply cut off—a procedure which, as stated, leads to the loss of all the "labile phosphorus"—and then permitted to recover, the reappearance of "labile phosphorus" is accompanied by the return of an equivalent quantity of creatine to the condition in which precipitation by copper does take place. Direct evidence for the synthesis of a creatine-phosphoric acid compound during recovery is thereby attained.

Quite aside from its obvious bearing on the mechanism of muscular contraction, the demonstration of "phosphocreatine" in muscle should go far towards providing an explanation for a number of matters which in the past have been obscure. Among these may be mentioned the passage of administered creatine into muscle in spite of the large quantity already there, and the striking difference between resting (living) muscle on one hand and fatigued or dead muscle on the other in their capacity for retaining both creatine and phosphate, as shown by perfusion and dialysis experiments.

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ON THE UPPER LIMIT OF VIBRATIONAL FREQUENCY THAT CAN BE RECOGNIZED BY TOUCH

IN relation to experiments on the transmission of speech instrumentally to organs of touch in the skin and to end organs of the sense of vibration it is of more than ordinary interest to discover what is the upper limit of vibrational frequencies that can be felt through these senses.

Landlois (*Lehrbuch d. Physiol. d. Menschen,* 1880) states that vibrations of strings are recognizable at a frequency of 1552 a second. This is the highest figure that has been published hitherto.

Dr. V. O. Knudsen, of the Department of Physics of the University of California, reports in a paper that is about to be published that his subjects reached no higher than 1600 d.v. a second. The stimulus was furnished by an oscillator and was applied through a reed slapping near the tip of the subject's middle finger.

In my experiments the stimuli are the vowel qualities *e, er, oo, o, ah* and *aw,* spoken into a high-grade microphone. A modified 25 B (Western Electric) two tube amplifier is in circuit. An electrical filter has been introduced also, and a five unit receiver or teletactor. Each of these instruments has been made for my use by the Bell Telephone Laboratories. The filter analyzes the speech frequencies into five bands: 0–250; 250–500; 500–1000; 1000–2000 and 2000 plus vibrations a second. Each band is led into one unit in the receiver and into no other. In the course of the experiments that are reported here connections have been broken so as to eliminate all but the highest band of frequencies—2000 d.v. and above.

When the vowel qualities already mentioned are pronounced into the microphone the subject feels the fifth reed that remains connected through the filter when it is in vibration. The figures below indicate the degree of the subject's accuracy of detection. He reported "yes" when he felt a vibration; otherwise he was silent. The stimulus is received through the finger nail or through the skin—preferably the former.

Total impressions—75
C. Subj.; G. Exp.

e	total	19	Vibrations.	Felt	15
er	"	13	"	"	0
oo	"	12	"	"	1
o	"	8	"	"	0
ah	"	10	"	"	3
aw	"	13	"	"	6
		75			25

O. Subj.; G. Exp.
Total impressions—74

e	total	18[1]	Vibrations.	Felt	18
er	"	13	"	"	7
oo	"	12	"	"	12
o	"	8	"	"	2
ah	"	10	"	"	3
aw	"	13	"	"	11
		74			53

The subjects in this test are both deaf. They can not hear speech. The experimenter, while the test

[1] Missed one *e*; finger off receiver.

was going on, was thirty-five feet from the subjects, behind two closed doors and standing upon a pile of papers and magazines to damp vibrations that may otherwise be assumed to reach the subject through the floor from the experimenter's body.

When connection was broken between the microphone and the receiver and the experimenter continued to pronounce as usual the subjects gave no sign of knowledge that anything was going on.

What the subjects felt may have been far above a frequency of 2000 a second. It was at least as high as that. High frequencies in the male voice run up as follows: *e,* 2987; *oo,* 3700; *er,* 3050; *o,* 3475; *ah,* 3683; *aw,* 3612, (Crandall, Sounds of Speech; *The Bell System Technical Journal,* IV, 4). In fact these figures are *next* above 1965 in Crandall's table. It is highly probable that our subjects are sensing vibrations that occur with a frequency approximating 3000 a second.

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POSSIBLE SOURCES OF SOME BOULDERS IN THE GLACIAL DRIFT OF MISSOURI

THE writer realizes that it is not an entirely safe procedure to identify a rock specimen, found in glacial drift, as having come from a certain locality, by comparing the megascopic characteristics of the specimen with the recorded descriptions of rocks from various localities. With a full realization of this uncertainty, the writer has endeavored to locate the original sources of some of the glacial boulders in the vicinity of Columbia, Missouri.

A large variety of rocks has been identified in the glacial drift in the vicinity of Columbia. These rocks include granites of various colors and varying coarseness of texture, dolerites, hornblendites, basalts, gneisses, both hornblende and mica schists, anorthosites, quartzites of various colors, conglomerates and a quartzose-looking rock. For most of these rocks, the writer has been unable to locate successfully their original sources. The last four rocks above mentioned are the ones about which the writer wishes to make a few remarks.

Anorthosite is not a common rock, being known to occur in relatively few places in North America. It is known to occur in the following localities: Adirondack Mountains, in Wyoming, several places in Canada, such as in the region of the headwaters of the Saguenay River, and north of Montreal, in the Lake Superior region in localities as Carlton Peak, Shingle Cove and other places. The writer believes that the anorthosite found in the glacial drift in the area under consideration came from the anorthosite localities along the west shore of Lake Superior. This is the only probable locality from which the anorthosite could have come.

The quartzites in the drift are largely the Sioux quartzite, which is the hard, red quartzite found in Minnesota, Iowa and South Dakota.

The conglomerate, which is of much interest locally, is a jasper conglomerate. The jasper pebbles are the red-banded and black-banded varieties. These pebbles, along with quartz pebbles, are firmly cemented with a siliceous cement. The conglomerate closely resembles a portion of the Ogishke conglomerate, of Huronian age, found in the Vermilion Range of Minnesota.

The "quartzose-looking" rock is a dark red, fine-grained rock containing sandy granules of red jasper. Grout,[1] to whom a sample was sent, says of it, in part—"I have never seen (it) in place anywhere except on the Mesabi range, as a part of the iron-bearing formation." It agrees with the description of the ferruginous chert which makes up a part of the iron-bearing formation in the Mesabi range.

The direction of movement of these rocks, if their original localities as stated be granted, was therefore from the north directly to the south, in almost a north-south line. The post-glacial movement, due to running water, is believed to be slight.

In the vicinity of Marysville, Nodaway County, Mo., and at Green City, Sullivan County, Mo., there have been found several pieces of native copper in the glacial till,[2] the age of the till being unknown to the writer. According to W. A. Tarr, one of the pieces of copper weighed about twelve pounds. The only logical locality from whence this copper could have come is the copper country of Upper Michigan.

Upham[3] states, "In Lucas County, of southern Iowa, a mass of drift copper weighing more than thirty pounds undoubtedly was borne by the currents of the ice-sheet about six hundred miles, from the present copper-mining region south of Lake Superior or from Isle Royal, first southwestward and later southward through eastern and southern Minnesota, passing west of the Wisconsin driftless area. Its journey probably was accomplished mostly during Nebraskan time."

The writer believes that the copper found in the northwestern part of Missouri was carried by the same currents of the ice-sheet that carried the copper to southern Iowa.

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[1] Personal communication with Dr. F. F. Grout.

[2] Personal communication with Dr. W. A. Tarr.

[3] Upham, W. "Stages of the Ice Age." Bull. G. S. A., Vol. 33, 1922, p. 501.